Irrigation and Energy Analysis: Initial Findings

Prepared For: SLO Creek Farms

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GROWING MORE, WITH LESS

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Table of Contents

The Purpose and Benefit of this Report

The purpose of this report is to identify sources of waste in terms of energy and water associated with irrigation at SLO Creek Farms. SLO Creek Farms has expressed interest in changing their current irrigation scheme to protect crop quality. However this need presents an opportunity to present a new system to optimize energy and water use. This report will investigate current challenges, offer a set of alternatives to protect crop quality while conserving water and energy, and briefly discuss new system implementation.

Existing System and Associated Issues

The current system at SLO Creek Farms uses a form of overhead sprinkler irrigation to water 40 acres of apple orchards. There is a fairly complex well system that taps into a relatively shallow groundwater basin. The complexity of the well system lies not in the hydraulic or distribution systems but in the multiple users of the well system. SLO Creek Farms, the San Luis Obispo Land Conservancy, the Gable Family, and possibly other domestic users have been identified as users of the well system. Thusly, at this time it is not well understood who is using what well, when, and how long they are using it for. This makes analysis of past energy statements difficult. Furthermore because of communication difficulties, details of the existing irrigation system are lacking. These details include pump specifications, more specifically pump brand, model numbers, and characteristics curves.

Putting aside what is unknown about the existing system, there is quite about that is known. Currently the orchard is irrigated via sprinklers that are a top a (roughly) 10 ft. tall riser pipe. For the system to provide adequate coverage it must operate at high pressures and for extended period of

Figure 1. Apple orchard using inefficient overhead spray irrigation.

time. Additionally it was discovered that four pumps most be operated simultaneously to obtain adequate pressures.

Figure 2. Two apples with apple scab

Irrigating the orchard in this manner has proved troublesome. Overhead water seems to be the chief cause of many diseases that the crop endures. Apple scab is the primary disease at SLO Creek Farms. This disease and others like it are propagated and fueled when the fruit is exposed extended periods of moisture, high winds, and rain. Long durations of overhead irrigation mimic these conditions very well.

In addition to disease and compromising the aesthetics of the fruit overhead watering is wasteful. Irrigating the crop in this manner exhibits high losses of water to wind and evaporation. In some instances as much as %50 or more of the water coming from overhead irrigation is lost to evaporation alone. Lastly, using overhead irrigation is energy intensive. Pumps must be operated at high pressures and at low flows to get adequate crop coverage. High pressures require high energy inputs and low flows require long watering durations creating a multiplier effect in terms of pump energy consumption.

Energy Analysis: Current Irrigation Scheme

Though exacting details regarding well pump and motor specifications, general hydraulic system layout, and current operational tactics are lacking a rough estimate of potential energy savings is examined. It is currently understood by the author that four pumps on the farm must be operated or at least *are* being

operated simultaneously to have adequate pressure and flow under the current irrigation scheme. This requires a total of 45 horsepower (HP) or 34 kilowatts (kW). For the year of 2011, looking at only two PG&E energy statements (the author presumes that each of the four wells is on its own meter), total energy requirements for pumping in the current irrigation scheme resulted in a total of 14300 kilowatts hours (kWh).

This means that if all four pumps were included on these two energy statements that they were operated for about 420 hours, resulting in $3000 being spent on pumping energy alone during the year of 2011. However if this bill does in fact represent the energy statement for only two wells then the total energy consumed for pumping would be nearly 30000 kWh (assuming that the bill would roughly double when accounting for double the number of similar pumps operating similarly) costing $6000 annually. Because the flowrates coming from each of these pumps is not known, the operating efficiency of each pump cannot be determined. However it is fair to assume they are operated within the range of %40-%80 efficient, with %80 percent efficiency being very high for most pumps.

Figure 3. Regular monitoring of power meters is a quick and easy way to gauge energy use.

To reduce pumping energy requirements, the pumping system needs to be operated at higher efficiencies and/or at lower horsepower. Shifting pump operating points at a given horsepower will only minimally effect power consumption relative to operating at a lower horsepower. Luckily all four of the pumps can be operated at a lower horsepower. However at the lower horsepower operating points, the pump will be able to deliver less pressure at a given flow. This jeopardizes the adequacy of continuing with current irrigation schemes.

Pumping Alternatives

There are still many unknowns about the hydraulics of the irrigation system. However there are some alternatives that can be employed with and without a full understanding of the system. Any one of these alternatives can be used alone or in conjunction with one another and will lower operating costs associated with pumping.

One such alternative is to pump only at night. This will lower pumping cost because pumping will occur at “off peak rate” hours. Nighttime irrigation will also reduce the amount of water lost to evaporation and evapotranspiration. In this report evaporation will mean water lost by evaporation before reaching the ground surface and evapotranspiration will mean water evaporated out of the soil and respired by the apple trees themselves.

Figure 4. Changing pump operation scheme may provide a low cost energy saving solution.

Another is to pump water from the ground to some sort of surface storage. From the surface storage water then can be pumped via a smaller, less energy consuming, booster pump to the orchard. While potentially saving energy (operating costs) this alternative is capital intensive and would require additional piping, tankage and pumps.

Lastly, the pumps can be operated at a lower horsepower. Lowering the operating point of the pumps will decrease energy consumption while still obtaining the same flow. This comes with the sacrifice of pressure. Losing pressure will require a change from high pressure

sprinkler irrigation to some low-pressure form of irrigation, namely, drip irrigation. This represents a potentially high capital cost as well, but not as high as the storage tank alternative.

Water Usage: Current Irrigation Scheme

SLO Creek Farms operates from a private groundwater supply. Thus far no information is known about volumetric water withdraw from any of the wells and can only be calculated making many assumptions and using the two well energy statements.

Assuming that the well system at SLO Creek Farms was pumping for 420 hours during the 2011 year, as estimated in the previous section of this report, is the basis for the water use estimates to follow. Another assumption is that all the pumps were operating, at 175 gallons per minute (GPM) at 200 feet of head or about 85 pound per square inch. The chosen operation point on which the analysis is based is within the operational capacity for all four pumps on the property.

Figure 5. High water losses can occur using sprinkler irrigation.

Water flowing at a rate of 175 GPM for 420 hours out of four pumps amounts to roughly 18 million gallons of water used in 2011. Most all of this irrigation occurred in the months of June, July August, and October. For the month of September, according to the energy statement, there was no pump energy usage, which is highly suspect and could be steering this estimate toward the conservative side.

Much of this water does not even benefit the crop. High evapotranspiration rates during the California summer persist, and cause high water loss before touching the ground let alone penetrating to the root zone. According to the table below and assuming all the water from the sprinklers makes it to the ground, SLO Creek Farms could be losing in the range of 2-6 gallons of water per day per tree from evapotranspiration alone.

If 2-6 gallons of water per day per tree are lost due to evapotranspiration then anywhere from 1000-3000gallons of water are wasted per acre per day, assuming all the water from the sprinklers reaches the ground. (This assumes that all acreage at SLO Creek Farms has the same tree number of trees per acre as the small plot near San Luis Bay Drive). According to a Google Maps area calculator tool SLO Creek Farms has about 60 acres of orchard. This means that SLO Creek Farms is losing about 60,000 to 180,000 gallons of water to evapotranspiration. Some study show that up water loss caused by evaporation (before the water touches the ground) is in the neighborhood of %50. This means that of 18 million gallons sprayed only 9 million gallons gets to the ground. And of the 9 million gallons on the ground up to 180,000 gallons will be lost in evapotranspiration, with net water loss nearing 9.2 million gallons of water a year.

Water Management Guide for Temperate Fruit Trees

Tree Size, or area plant covers in square feet (ft^2) to the drip line (% canopy)	Daily Water Use in Gallons per Day			
	E.T. 0.10"/day Cool day, early spring Late fall, foggy	E.T. 0.20"/day Warm day in spring or fall; some fog	E.T. 0.25"/day Hot day, mid-summer No fog	E.T. 0.30"/day Very hot (100°F) Windy, mid-summer
1 $foot^2$	0.062	0.125	0.156	0.187
1 yr. old (4 ft^2)	0.25	0.50	0.62	0.75
2 yr. old (10 ft^2)	0.62	1.25	1.56	1.87
3 yr. old (36 ft^2)	2.25	4.5	5.61	6.73
4 yr. old or 100 ft^2 semi-dwarf mature	6.20	12.5	15.6	18.7
Large standard mature tree (300 ft^2)	18.6	37.5	46.8	56.1
One acre solid cover (43,560 ft^2)	2,715	5,431	6,788	8,146

From: Growing Temperate Tree Fruit and Nut Crops in the Home Garden
Paul M. Vossen
Tree Fruits and Nuts Farm Advisor, Sonoma and Marin Counties
University of California Cooperative Extension
2000

Irrigation Alternatives

The ideal solution in terms of an irrigation scheme’s energy and water consumption is to not irrigate at all. This is otherwise known as

dryland farming or dry farming. Neighboring apple orchards have been doing this for many years with great success even though they are located further from San Luis Creek than SLO Creek Farms and presumably have a greater depth to the groundwater table. However this implies a certain amount of risk to SLO Creek Farms. The risk lies in the uncertainty of crop yield as a result of not irrigating. Maintaining the current irrigation infrastructure does provide a safety net, in the event the crop demonstrates any mal-effects from not irrigating.

Another irrigation solution would be to use drip irrigation. Drip irrigation will provide the following benefits:

Figure 6. Young orchard using drip irrigation.

1. Eliminate the fruit's extended exposure to moisture caused by overhead sprinklers

2. Reduce water lost to evaporation and wind

3. Reduce pump energy requirements

4. Provide operational flexibility for flood resistance, dry farming, and/or optimization

Drip irrigation is the most widely used form of orchard irrigation and should be more than adequate in service of SLO Creek Farms.

A third irrigation alternative is to use soaker hose in lieu of drip irrigation. Soaker hose will provide many of the mentioned benefits of drip irrigation however will be less water efficient, and could provide increased flood resistance.

Recommendations

After conducting this initial study it is easy to see that SLO Creek Farms has room to improve operating efficiency. There are many missing pieces of information that could lead to a differing set of recommendations or supersede recommendations herein; however this manual will provide some suggestions based on current knowledge.

For SLO Creek Farms to have a yield that is sellable, reducing aesthetic damages to the crop is imperative. This means limiting the fruit's exposure to moisture. This is the basis for the suggestion to switch to drip irrigation. Drip irrigation will put water directly to the ground, eliminating extended periods of moisture endured by the fruit. Using drip irrigation will also save SLO Creek Farms water. Less water in the air means less water evaporating before touching the ground. More efficient water use will lead to less pumping and thereby decreasing energy costs.

Switching to drip irrigation will require a change in pumping operations. Currently the pumping scheme is operated at pressure that would exceed the strength of most drip lines. With the information at hand SLO Creek Farms should be able to continue using their current groundwater pumps. The pumps will just need to be operated at a lower horsepower. This may require changing the pump motor from a high horse power motor to a lower horsepower motor. Operating at a lower horsepower will decrease pressures in the system while still maintaining sufficient flow.

Figure 7. Water and energy conservation are key to sustainability.

In the event that SLO Creek Farms does employ one these recommendations, it first should be attempted on a small "experimental plot". Irrigating in any new manner is probably best first tried on an experimental plot. First this will minimize the risk involved in the event that the new irrigation scheme does not work.

Secondly this will allow for a side by side and real time comparison between the new “experimental” method and the existing method.

Energy and Water Savings

As demonstrated previously SLO Creek Farms uses significant amounts of water. Much of this water evaporates before even touching the ground and 2-6 gallons of water per tree are lost once the water does reach the ground in the form of evapotranspiration. By switching to drip irrigation the massive evaporation losses are virtually eliminated, saving around 9 million gallons of water.

Figure 8. Conserving water and energy will not only save SLO Creek Farms money, but add to its organic image.

Energy costs are also reduced by switching to a drip irrigation scheme. Currently the irrigation system requires four pumps to be operated at 15 HP or 45 HP total. This high power requirement stems from the need of high pressure to operate sprinklers. Once switched to drip irrigation the farm will need to lower the system’s operating pressure. This is done by lowering the power input from the motor to the pump. In general the current pumps on the farm can be operated at 5 HP. Operating at the lower power input will provide the lower pressure necessary for drip lines without sacrificing adequate flow rates. Operating four pumps at 5 HP for a total of 20 HP (or 15 kW) rather than 45 HP will result in %66 energy bill savings annually (assuming 420 hours of pumping per year).

The above estimates are believed to be conservative and SLO Creek Farms will likely see greater energy bill reductions than outlined here. This is because of the synergistic effect of switching to drip coupled with lower pumping pressures. Using drip irrigation will

require less water and thus, less pumping time. Less pumping time at a lower power consumption rate will result in a multiplier effect in energy savings.

Implementation

Implementing the proposed solution should be relatively straight forward. Drip irrigation can be attached directly to the existing riser pipes. All the riser pipes encountered at the farm had a female-female coupling about 5ft above the ground. Simply unscrewing the coupling and attaching two 90 degree elbows connected to a drip line should be the all that is required for assembly.

Figure 9 Appurtenances required for drip line to connect to existing riser pipes.

Additional appurtenances such as pressure regulators, pressure regulators, in-line filters may also be added to ensure long term functionality and reduce maintenance needs.

Because the drip line needs to be flood resistant, it is recommended that SLO Creek Farms chose a drip line with integrated emitters. The emitters should be as far apart as possible with the ideal spacing equal to the spacing between trees. This will allow the line to be retracted before the rainy season and potential flooding. Drip lines

with external emitters would break off and compromise operational efficacy.

Figure 10 Representative dripline with in-line emitters.

Typical drip lines operate at pressures on the order of 10psi to 30psi. The current irrigation system operates at pressures on the order of 180psi. All pump data obtained thus far implies that the pumps can be operated at pressures consistent with typical drip lines. All that may be required is switching out the current motors or lowering the motors' output to the lower operating points such that pressure output by the pumps will match that of the drip line.

Future Scope

There is still further work that is needed for accurate analysis and an integrated solution. As it stands this report is based on rather limited information and requires further investigation. The following list details some of the items of greatest concern:

1. Detailed mapping of SLO Creek Farms pump-irrigated acreage

2. Obtain irrigation system layout

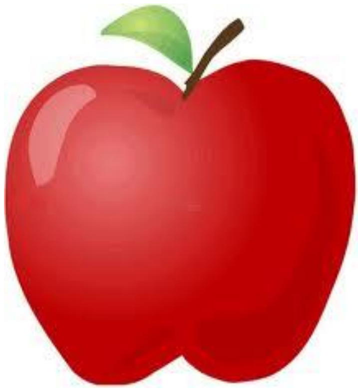
3. Obtain all PG&E billing information for meters with pump motors

4. Design a reel system to retract drip line before flood season

5. Measure groundwater withdrawals

6. Set up experimental irrigation plot

7. Communicate with SLO Land Conservancy about management of their pumps on SLO Creek Farms property



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